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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Gadgil et al.
Appl. No.	:	10/043,647
Filed	:	January 10, 2002
For	:	UV WATER DISINFECTOR
Examiner	:	Christopher M. Kalivoda
Group Art Unit	:	2881

DECLARATION OF ASHOK GADGIL OF PRIOR INVENTORSHIP UNDER 37 C.F.R. §1.131

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

This declaration is to establish an invention date of embodiments claimed in the above-captioned application before January 12, 2000, the publication date of "Cryptosporidium Inactivation By Low Pressure UV in a Water Disinfection Device," an article by Drescher, Greene, and Gadgil (the "Drescher article"). I, Ashok Gadgil, do hereby declare that:

1. My name is Ashok Gadgil.
2. I earned degrees in Physics at the University of Bombay (B.Sc. 1971) and the Indian Institute of technology at Kanpur (M.Sc. 1973). I then moved to the United States to complete my education at the University of California at Berkeley (M.A. 1975, Ph.D. 1979).
3. From 1980-1983, I worked at the Lawrence Berkeley National Laboratory (LBNL) as a Staff Scientist in the Energy and Environment Technology Division, where I created computer programs that were later used worldwide to run simulations of solar heat transfer systems.
4. From 1983-1988, I worked at a research institute in New Delhi, in the area of electrical power efficiency and conservation.

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5. In 1988, I returned to LBNL, where I have been working ever since. I am now a Senior Staff Scientist at LBNL. I have worked significantly in the area of energy efficiency, especially as a means of improving quality of life in developing countries. I have also become an expert in protecting people from toxins and pollutants.
6. I am one of the named inventors of the above-captioned patent application and am familiar with the prosecution of the application, including the Response to Final Office Action accompanying this Declaration.
7. I am advised that certain pending claims of the above-captioned application have been rejected under 35 U.S.C. §102(b) as being anticipated by Gadgil et al., U.S. Patent No. 5,780,860. One of the pending claims has been rejected under 35 U.S.C. §103(a) as being unpatentable over Gadgil et al., U.S. Patent No. 5,780,860, in view of Kool et al., U.S. Patent No. 6,533,930. Certain other pending claims have been rejected under 35 U.S.C. §103(a) as being unpatentable over Gadgil et al. Other pending claims have been rejected under 35 U.S.C. §103(a) as being unpatentable over Gadgil et al., in view of the Drescher article.
8. Along with Eduardas Kazakevicius and Anushka Drescher, I jointly invented the claimed invention in the above-captioned application, which involves an apparatus for low-cost UV disinfection of household tap water.
9. My co-inventors and I developed the UV Compact Unit for manufacture by WaterHealth International ("WaterHealth"). This unit is substantially identical in relevant aspects to the UV disinfector disclosed in the above-captioned patent application.
10. Exhibit A is a copy of a progress report entitled "Development of Compact UV Water Disinfection Unit., Progress Report" (the "Progress Report"). The Progress Report was prepared by Eduardas Kazakevicius, one of the named inventors of the claimed invention of the above-captioned application. The

Progress Report describes the work done to reduce the invention to practice. This report antedates the publication date of the Drescher article.

11. The Progress Report describes in detail the work that was done to complete the design for the UV Compact Unit, which is designed to deliver maximum UV radiation dosage with substantially uniform UV distribution at maximum water depth under the worst conditions (for example, 0.3/cm absorption in this case). The Progress Report includes a description of a mathematical model for simulation of UV radiation distribution in water. Calculated results were also tested using a prototype of the UV Compact Unit, which included an air suspended UV lamp, gravity flow through the treatment chamber, and low flow rates suitable for treating flow from a household tap.
12. The Progress Report does not describe a prototype UV Compact Unit having a household tap connector. In conceiving the invention and designing the UV Compact Unit, we had household use in mind, *i.e.*, a unit intended for use with water from a household tap. The subsequent actual reduction to practice of the invention, including the household tap connector, occurred prior to the publication date of the Drescher Article.
13. Actual reduction to practice of the claimed invention was thus completed prior to the publication date of the Drescher Article.
14. The work that led to the invention claimed in the above-captioned application was performed in the United States.
15. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful, false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful, false statements may jeopardize the validity of the application or patent issuing therefrom.

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Respectfully submitted,

Dated: May 20, 2004

By: A J Gadgil
Ashok Gadgil

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EXHIBIT A

Edas Kazakevicius

Development of Compact UV Water Disinfection Unit, Progress Report

[DATE REDACTED]

UV Radiation Distribution Calculation

A mathematical model for simulation of UV radiation distribution in water was developed using MathCad 7 Professional software package. The model included UV light refraction and reflection on water surface for different angles of incidence and absorption of UV radiation in water for different extinction coefficients. Calculation results of the model were in good qualitative agreement with test results (see section below). Some quantitative differences between calculated and measured results can be explained by influence of simplifications assumed in the model, slight difference between calculated and measured variables (calculated intensities (mW/cm2) were normal to the beam, whereas measured intensities were mainly normal to water surface with certain contribution of radiation from other directions decided by angular characteristics of UV sensor) and unknown absolute power of UV lamps (rated power does not necessarily correspond to the actual power of the lamp). Calculations were mainly concentrated around two 18W UV lamp configuration because this would ensure sufficient UV exposure levels at 4 - 5 l/min flow rate and compact design of disinfection unit. Simple calculations show that to treat water with 0.3/cm extinction coefficient an optimal depth of a tray should be around 3 – 3.5 cm. Assuming uniform distribution of UV radiation at the bottom of the water tray, the average minimum exposure exceeds 90 mWs/cm2 for 0.3/cm absorption coefficient, 3 cm water depth, 50% reflection losses and 5 l/min flow rate (Note: that the actual minimum exposure could be less than 90 mWs/cm2 due to chaotic hydrodynamic characteristics of water flow). The major task is to design a system able to deliver maximum UV radiation dose with rather uniform distribution at the maximum water depth under the worst conditions (0.3/cm absorption coefficient in our case). Main calculation results are presented in the Appendix of this report.

Conclusions: Mathematical model developed by WHI can be used for qualitative analysis of UV radiation distribution under water for different absorption coefficients. Assuming uniform distribution of UV radiation at the bottom of 3 cm depth tray, the average minimum exposure in the tray is not less than 90 mWs/cm2 (0.3/cm absorption coefficient, 5 l/min flow rate, and 50% reflection losses).

Current status: The task is completed.

File names (comments): MathCad 7 files: TR3 (lamp height above water surface h=3 cm, for different depths, d=2,3,4 cm), TR4 (lamp height above water surface h=4 cm, for different depths d), TR5(lamp height above water surface h=5 cm, for different depths d), TR13 (lamp height above water surface h=1 cm, water depth d=3 cm), TR23 (h=2cm, d=3cm), TR33(h=3cm, d=3cm), TR31(h=3cm, d=1cm), TR32(h=3cm, d=2cm), TR34(h=3cm, d=4cm), TR35(h=3cm, d=5cm), TR42 (h=4cm, d=2cm), TR43 (h=4cm, d=2cm), TR52 (h=5cm, d=2cm), TR53 (h=5cm, d=3cm). All other parameters of the equations (like absorption coefficient k, 1/cm) can be changed (for each of these files height of lamps and water depths must remain unchanged). Avtr3 is average minimum dose assuming uniform distribution of UV radiation at the bottom of a tray.

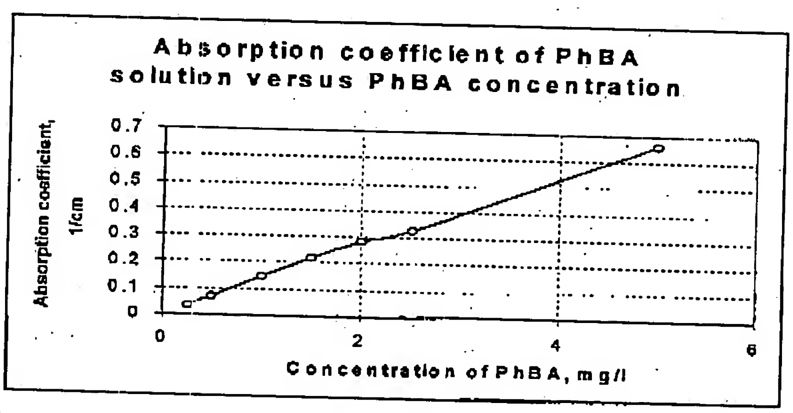
UV Radiation Distribution Test Results

Calculation results were tested using an experimental setup consisting of plastic water tray with quartz windows at the bottom, two 18 W UV lamps each emitting 5.5 W of UV radiation at 254 nm wavelength (TUV PL-L 18W Philips "long life" germicidal lamp), several top reflectors of different shape, and UV meter IL-1400A. Absorption coefficient of water was varied by adding different amounts of PhBA solution (see section below). Distribution of UV radiation at different depths was measured for different extinction coefficients, and for different lamp and tray

configurations. Measurement results (see Appendix) indicated that mathematical modeling results ar in rath r good agreement with test results, and can be used for qualitative analysis.
A number of measurements were conducted with different shape top reflectors to maximize unit's disinfection performance. Test results (see Appendix) indicated that one of the best solutions is to use almost rectangular top reflector with slightly rounded corners placed 1 – 2 cm above UV lamps (Note: lamps are in line with water flow). Unfortunately changing absorption coefficient of PhBA solution did not allow us to elaborate another option of unit design with UV lamps placed perpendicular to water flow.
Test results showed that it is possible to reach quite uniform 8 mW/cm2 UV intensity at the bottom of 3 cm deep tray filed with PhBA water solution (0.3/cm). At 5 l/min flow rate this intensity would translate into average minimum dose of approximately 90 mWs/cm2.
Conclusions: Test results indicate that two 18 W germicidal lamps would provide average minimum dose of 90 mWs/cm2 at the bottom of 3 cm depth tray for challenge water with 0.3/cm extinction coefficient at 5 l/min flow rate. Top reflector in this case should be almost rectangular with slightly rounded corners placed 1 – 2 cm above UV lamps.
Current status: The task is completed.
File names (comments): MS Excel files: UVNRefl (calculated and measured intensities of UV radiation with and without top reflector at different water depths for different lamp heights above water surface and different distances between lamps). MS Word [REDACTED] files: Calc–Test 0, Calc-Test1, Calc-Test2, Test-Calc3, Calc-Test4, Calc-Test5 (results of calculations and measurements in comparison).

Tests of p-HydroxyBenzoic Acid (PhBA), UV Absorbing Additive to Water

To achieve necessary UV absorption coefficient of challenge water the PhBA solution was used. To develop a calibration curve for the measurements we prepared an initial solution by adding 25 milligrams of PhBA powder into 1 liter of DI water. Then we took different amounts of the initial solution (10 ml, 20 ml, 40 ml, 60 ml, 80 ml, 100 ml, and 200 ml) and mixed that with approx. 1 liter of DI water (100 ml and 200 ml of the initial solution was mixed with 0.9 and 0.8 l of DI water respectively), thus making 7 solutions with PhBA concentrations of 0.25; 0.5; 1; 1.5; 2; 2.5; 5 milligrams per liter. UV absorption coefficients of these solutions are presented in the figure below. Unfortunately the resulting absorption coefficient is changing with time if water with PhBA remains exposed to UV for a longer time (more than 10 minutes), therefore UV absorption of challenge water must be checked twice in the beginning and at the end of the measurement.



Conclusions: PhBA solution can be used for changing absorption coeffici nt of challenge water with some caution (the absorption coefficient is changing with time if water with PhBA remains exposed to UV for a longer time period).
Current status: The task is completed.
File names (comments): PhBA (MS Excel file).

Major Design Features of Compact UV Disinfection Unit

Calculation and measurement results show that the optimum performance (rather uniform UV radiation distribution and maximum dose at the bottom of the tray) can be achieved for the following dimensions of UV system (see Appendix for detailed drawings): water depth in the stainless steel tray – 3 cm (tolerance ~ 0.5 cm); two 18W TUV lamps separated by 10 cm (tolerance ~ 0.5 cm) placed 3 cm above water surface (tolerance ~ 0.5 cm) in line with water flow; UV exposure chamber of the stainless steel tray should be 16 cm wide (tolerance ~ 0.5 cm); top aluminum reflector must be placed approximately 2.5 cm above UV lamp centerline (tolerance ~ 0.5 cm); the length of exposure section of the stainless steel tray should be 21 cm (tolerance ~ 1 cm); stainless steel tray must be formed from a single sheet of stainless steel; top reflector shape must be almost rectangular with rounded corners formed preferably from the single piece of aluminum; back wall of inlet section of the tray must have a V-notch or overflow hole for both overflow control and unit leveling; production unit must have shut-off valve triggered by either voltage drop, or preferably by high frequency current (voltage) detector.
Conclusions: Main characteristics of the compact unit are: UV exposure section of the stainless steel tray is 16 cm wide, 21 cm long with water depth equal to 3 cm. Two 18W TUV lamps must be placed 3 cm above water surface and separated by 10 cm. Rectangular top reflector with rounded corners must be placed 2.5 cm above UV lamp centerline. Both stainless steel tray and aluminum top reflectors should be preferably formed from single sheets of stainless steel and aluminum correspondingly. Shut-off valve is a must.
Current status: The task is partly completed. We agreed with Perrin Manufacturing Co. on the drawings of a single stainless steel tray (see Master4). Drawings of top reflector still need to be worked out.
File names (comments): Maindimensions (AutoCAD LT file, cross section of UV exposure chamber, all dimensions in cm). Maindimensions1 (AutoCAD LT file, UV exposure chamber, top view, all dimensions in cm). Master4 (AutoCAD LT file, stainless steel tray, all dimensions in cm). Refl1, Refl0, etc. (AutoCAD LT files, top aluminum reflector options, all dimensions in cm).

Hydrodynamic Test Results of the Initial Prototype

To test hydrodynamic performance of UV compact unit Perrin Manufacturing Co. produced prototypes of stainless steel tray and top reflector. The hydrodynamic characteristics of the stainless steel tray were tested using portable pH meter (Cole-Parmer pHTestr 1), vinegar and food grade dyes. Initial performance of the prototype was tested visually by adding some dye into inlet chamber of the tray. More exact picture of the hydrodynamic performance was tested by adding 2-3 ml of vinegar into inlet chamber of the tray (next to perforated baffle) and measuring pH of running water with pH meter. In each case pH was measured for two depths – very close to the water surface (top layer) and at approximately 2 cm water depth (bottom layer). Transit time of each run was measured from the moment of vinegar injection to the moment when water pH drops by 0.1 (first breakthrough). The results of pH tests are presented in the Appendix of this report. Results of transit time measurements at 2 cm depth can be lowered by 1 s compared with results of surface flow, because wall before outlet section was rounded and thus pH meter had to

be placed approximately 1 –2 cm away from the outlet. Water pH was changing from 8.8 to 3.8 – 4.0 during each run (4 – 5 log reduction), so that pH drop by 0.1 is quite reasonable representation of situation when the first bacteria out of 10 – 100 thousands reaches outlet chamber. Unfortunately, manufacturing quality was poor, so we had to use plumber's putty to adjust bottom tray dimensions for our test, so that absolute numbers of our tests should be considered with precaution. Nevertheless, conducted results indicated that the best location of inlet assembly is in the middle of the inlet section at the bottom. If unit is properly leveled and inlet assembly is properly aligned, the minimum passage time between inlet and outlet sections was 8 seconds and more. Absolute minimal dose in that case (assuming 8 mW/cm2 intensity, 0.3/cm absorption coefficient and 3 cm maximum depth) exceeds 60 mWs/cm2. If one side or end of the stainless tray is tilted (by 0.5 – 1.0 cm), or inlet assembly is not properly aligned the passage time can go down to 6 s (40 mWs/cm2 minimum dose). These results indicate that reasonable leveling of the unit can be achieved by the methods already implemented in the current unit design (water surface must be leveled at 5 mm below V-notch). Hydrodynamic tests will have to be repeated when final prototype of the stainless steel tray is manufactured.

Conclusions: Hydrodynamic test results showed that the best location of inlet assembly is in the middle of inlet section at the bottom of stainless steel tray. Minimum water passage time through UV exposure section in that case always exceeded 8 s, therefore absolute minimum dose in case of proper leveling of the unit should always exceed 60 mWs/cm2. If unit leveling is improper, minimum passage time can go down to 6 s. V-notch, or overflow hole should be an adequate measure to ensure proper unit leveling (if water level is set at certain height below V-notch or overflow hole). Unfortunately, poor manufacturing of the initial prototype does not allow us to make final conclusions regarding minimum passage time and hydrodynamic tests will have to be repeated with the final prototype.

Current status: The tests of the initial prototype are completed.

File names (comments): AutoCAD LT files: UVChydro1 – UVChydro10 (test results of the stainless steel tray without putty inserts), UVChydro10N – UVChydro17N (measurement results of the tray with putty inserts).

Results of Bacteriological Tests of the Initial Prototype of Compact UV Disinfection Unit

Germicidal performance of the compact unit prototype was evaluated using an experimental setup consisting of water tank, submersible pump, water flow meter and prototype unit. Poor manufacturing quality of the initial prototype does not allow to make final conclusions about unit's performance, nevertheless the test provided initial information about germicidal performance of the unit design. The initial prototype was challenged by distilled water (absorption coefficient close to 0.01/cm) with E-coli bacteria. Minimal UV dose inside the unit exceeded 200 mWs/cm2 (flow rate was about 4 l/min). Water tank was filled with 12 l of distilled water and 1 ml of concentrated E-coli stock with nutrient was added (approx. 10^8 E-coli). For approximately 1 minute water was run through the unit with UV lights switched off and two 100 ml samples of water were taken (flow rate was around 4 l/min). Afterwards UV lamps were switched on and after some time (2-3 minutes for lamps to warm up) water was run at 4 l/min flow rate through operating unit. Three 100 ml samples of water were taken during this time. We used membrane filtration method for analysis of water samples. Sampled water was filtered using GelmanSciences 0.45 micrometer filters, which then were placed in Petri dishes filled with m-Endo medium for the analysis of total coliforms. The results are presented in the table:

	Before UV treatment (two samples)	After UV treatment (three samples)
E-coli concentration per 100 ml	(1.35 / 139) *10^6	0 / 0 / 0
Average E-coli concentration per 100 ml	1.37*10^6	< 1

The initial results show that prototype unit is able to achieve 6 log reduction of E-coli concentration in water at 4 l/min flow rate (for distilled water). Further tests of germicidal performance should include repetition of previous test using challenge water with different absorption coefficients, as well as different turbidity. It would be quite rational to manufacture new prototype model with dimensions corresponding to the design dimensions, because the current prototype has a number of defects.

Conclusions: The initial results show that the prototype unit is able to achieve 6 log reduction of E-coli concentration in water at 4 l/min flow rate (for distilled water). It must be decided whether to proceed with further tests using the current prototype, or to manufacture the prototype strictly corresponding to the designed dimensions. Future tests would include challenging the prototype unit with high turbidity water and PhBA water solution (0.3/cm absorption coefficient).

Current status: Only the initial tests were conducted. The task needs to be completed.

File names (comments): none

Design Proposals for UV Compact Disinfection Unit

For the final design of the compact disinfection unit several features are important (see drawings in the Appendix). Electronic compartment of the unit has to be completely sealed from the rest of the unit. One pair of cables should go from the electronics compartment to shut-off valve, and six (or eight, depending of ballast) wires from ballast should go from the compartment to the lamps. It would be preferable to have these connections between electronic compartment and the rest of the unit watertight. Feasibility of going to universal 12 VDC power supply must be explored. Electric safety issues regarding possibility of getting electric shock from high frequency current going from electronic ballast to the lamps must be explored. It would be preferable to have shut-off valve to triggered by high frequency current detector. If WHI decides to incorporate UV sensor in the compact unit it is worth exploring an opportunity of having one UV diode with filter of visible light (could be cheaper), instead of installing two UV diodes with quartz and glass windows.

List of essential parts for the compact UV disinfection unit:

- TUV PL-L 18W "long life" germicidal lamp (two units);
- MagneTek CBL – 218/120 ballast (for 120 VAC power supply). For 12 VDC and 220 VAC power ballast is yet to be determined (need to consult MagneTek);
- GC watertight solenoid valve (the same as for the standard unit).

Conclusions: Electronics compartment of UV compact disinfection unit should be separated from the rest of the unit. Shut-off valve should be operated either by external power, or by high frequency current (voltage) detector. 12 VDC power supply option should be explored. Electric safety issues regarding high frequency current should be explored.

File names (comments): UVhousing10 (AutoCAD LT file, side view of compact UV disinfection unit, proposal. All dimensions are in cm). UVhousing6 (AutoCAD LT file, top view of compact UV disinfection unit, proposal. All dimensions are in cm). UVhousing7 (AutoCAD LT file, end view of compact UV disinfection unit, proposal. All dimensions are in cm). UVhousing5 (AutoCAD LT file, side view of compact UV disinfection unit, partly disassembled, proposal. All dimensions are in cm).

Edas Kazakevicius

To Do List

At this stage of the development we have an initial prototype of UV compact unit designed, manufactured and tested (bacteriological tests are still incomplete). Unfortunately poor manufacturing quality of the initial prototype did not allow us to get final actual numbers of unit's performance, therefore manufacturing and testing of the final prototype (as close to the anticipated final design as possible) for its hydrodynamic and bacteriological performance is needed. Before final prototype is manufactured a number of problems and tasks have to be resolved:

- **Lamp holders**: in the current unit all lamp holders (BAX TECHNOLOGIES) are left sided (i.e. aluminum angle is on the left side of the lamp holder). We need to figure out if there is a possibility to order right sided lamp holders; so that for a compact unit we could use one left and one right sided lamp holder. If not, we need to find a way to mount two one sided lamp holders on the top reflector. Test if additional lamp holders from another side of reflector are needed.
- **Water drain** from the tray if unit is non-operational for an extended time periods: to explore a possibility of draining the inlet part of the stainless steel pan.
- **Filter** for giardia and other cysts: to explore a possibility of incorporation of a filter able to filter out giardia and other cysts.
- **High frequency current (voltage) detector**: try to design and test a sensor that would be able to detect high frequency current between ballast and UV lamp. Use this sensor to trigger shut-off valve if lamp is non-operational (no current at all, or starting voltage pulses).

UV Compact Disinfection Unit Cost Considerations

Manufacturing costs of the compact UV disinfection unit are based on the price list of spare parts for the standard unit provided by Perrin Manufacturing Co., as well as on preliminary information provided by manufacturers of UV lamps (Philips), ballast (MagneTek), valve (GC Valves) and universal 12 VDC power supplies. Total labor costs for an assembly of a compact unit are assumed to be $ [REDACTED] / unit.

Part	Quantity	Price of the part per unit in the current design, or manufacturers preliminary price, US $ (minimum order if available)	Expected total cost of the parts in the compact design, US $
TUV PL-18W lamp, Philips	2	[COST REDACTED]	[COST REDACTED]
CBL – 218/120 ballast, Magnetek	1	[COST REDACTED]	[COST REDACTED]
GC solenoid valve	1	[COST REDACTED]	[COST REDACTED]
SSAC delay timer	1	[COST REDACTED]	[COST REDACTED]
Stainless steel tray	1	[COST REDACTED]	[COST REDACTED]
Perforated baffle	1	[COST REDACTED]	[COST REDACTED]
Aluminum reflector, top	1	[COST REDACTED]	[COST REDACTED]
Fuse holder plus fuse	1 + 1	[COST REDACTED]	[COST REDACTED]
Lamp holder	2	[COST REDACTED]	[COST REDACTED]
Power chord	1	[COST REDACTED]	[COST REDACTED]
Manifold Assy	1	[COST REDACTED]	[COST REDACTED]
Legs	2	[COST REDACTED]	[COST REDACTED]
Top housing	1	[COST REDACTED]	[COST REDACTED]
Bottom housing	1	[COST REDACTED]	[COST REDACTED]
Misc. mechanic	-	-	[COST REDACTED]
Misc. electric	-		[COST REDACTED]
Labor			[COST REDACTED]
Total minimum			[COST REDACTED]
Total maximum			[COST REDACTED]
12 VDC power supply	1	-	[COST REDACTED]
Total minimum with 12 V DC power supply			[COST REDACTED]
Total maximum with 12 V DC power supply			[COST REDACTED]

Conclusions: It will be very difficult to manufacture a compact UV disinfection unit for less than $ [COST REDACTED] a piece, but at reasonable manufacturing quantities (5000 – 10000 units per year) it is possible to reduce the unit cost bellow $ [COST REDACTED]. 12 VDC universal power supply amounts to approx. 20% of overall unit cost.

To Do List

At this stage of the development we have an initial prototype of UV compact unit designed, manufactured and tested (bacteriological tests are still incomplete). Unfortunately poor manufacturing quality of the initial prototype did not allow us to get final actual numbers of unit's performance, therefore manufacturing and testing of the final prototype (as close to the anticipated final design as possible) for its hydrodynamic and bacteriological performance is needed. Before final prototype is manufactured a number of problems and tasks have to be resolved:

- **Lamp holders**: in the current unit all lamp holders (BAX TECHNOLOGIES) are left sided (i.e. aluminum angle is on the left side of the lamp holder). We need to figure out if there is a possibility to order right sided lamp holders, so that for a compact unit we could use one left and one right sided lamp holder. If not, we need to find a way to mount two one sided lamp holders on the top reflector. Test if additional lamp holders from another side of reflector are needed.
- **Water drain** from the tray if unit is non-operational for an extended time periods: to explore a possibility of draining the inlet part of the stainless steel pan.
- **Filter** for giardia and other cysts: to explore a possibility of incorporation of a filter able to filter out giardia and other cysts.
- **High frequency current (voltage) detector**: try to design and test a sensor that would be able to detect high frequency current between ballast and UV lamp. Use this sensor to trigger shut-off valve if lamp is non-operational (no current at all, or starting voltage pulses).

Edas Kazakevicius

Appendix

1. **AVTR3** (Mathcad file). Average minimal dose of UV radiation assuming uniform distribution of UV light at the bottom of the tray for different absorption coefficients, flow rates and water depths.
2. **TR33** (Mathcad file). Distribution of UV radiation at 3 cm water depth (absorption coefficient = 0.3/cm) beneath two 20 cm UV lamps located 3 cm above water surface and separated by 10 cm.
3. **Calc-Test** (MS Word [REDACTED] file). Calculated and measured UV intensities from two UV lamps separated by 11 cm at 3 cm water depth (k=0.25/cm) for different lamp heights above water surface (3,4 and 5 cm).
4. **Calc-Test1** (MS Word [REDACTED] file). Calculated and measured UV intensities from two UV lamps separated by 9 cm at 3 cm depth (k=0.25/cm) for different lamp heights above surface (3,4 and 5 cm).
5. **Calc-Test2** (MS [REDACTED] Word file). Calculated and measured UV intensities from two UV lamps separated by 12 cm at 3 cm water depth (k=0.25/cm) for different lamp heights above water surface (3,4 and 5 cm).
6. **Test-Calc3** (MS [REDACTED] Word file). Calculated and measured UV intensities from two UV lamps separated by 12 cm at 3 cm water depth for different lamp heights above water surface (3 and 5 cm) and absorption coefficients (0.1 and 0.18 per cm).
7. **Calc-Test4** (MS [REDACTED] Word file). Calculated and measured UV intensities from two UV lamps separated by 12 cm at 2 and 3 cm water depth (k=0.25/cm), lamps are 4 cm above water surface.
8. **Calc-Test5** (MS [REDACTED] Word file). Calculated and measured UV intensities from two UV lamps separated by 12 cm at 1 and 3 cm water depth (k=0.25/cm and 0.2/cm). lamps are 5 cm above water surface.
9. **UVNRefl** (Excel file). UV Intensity from two 18W lamps separated by 10 cm at 3 cm water depth (k=0.2/cm; lamps are 3 cm above water surface) for different reflector shapes.
10. **UVNRefl** (Excel file). UV Intensity from two 18W lamps separated by 11cm at 3 cm water depth (k=0.25/cm; lamps are 4 cm above water surface) for different reflector shapes.
11. **Maindimensions** (AutoCAD LT file). Cross section of UV exposure chamber, all dimensions in cm.
12. **Maindimensions1**(AutoCAD LT file). UV exposure chamber, top view, all dimensions in cm.
13. **Master4** (AutoCAD LT file). Stainless steel tray, all dimensions in cm.
14. **Refl1** (AutoCAD LT file). Top aluminum reflector, all dimensions in cm (one of the options).
15. **UVChydro12N** (AutoCAD LT file). Minimum transit time through UV exposure chamber at the surface and bottom water layers for different inlet assembly locations.
16. **UVChydro13N** (AutoCAD LT file). Minimum transit time through UV exposure chamber at the surface and bottom water layers for different inlet assembly locations.
17. **UVChydro14N** (AutoCAD LT file). Minimum transit time through UV exposure chamber at the surface and bottom water layers for different inlet assembly alignment.
18. **UVChydro15N** (AutoCAD LT file). Minimum transit time through UV exposure chamber at the surface and bottom water layers for properly leveled and tilted tray positions.
19. **UVChydro16N** (AutoCAD LT file). Minimum transit time through UV exposure chamber at the surface and bottom water layers for properly leveled and tilted tray positions.
20. **UVChydro17N** (AutoCAD LT file). Minimum transit time through UV exposure chamber at the surface and bottom water layers for properly leveled and tilted tray positions.
21. **UVhousing10** (AutoCAD LT file). Side view of compact UV disinfection unit (proposal). All dimensions are in cm.
22. **UVhousing6** (AutoCAD LT file). Top view of compact UV disinfection unit (proposal). All dimensions are in cm.
23. **UVhousing7** (AutoCAD LT file). End view of compact UV disinfection unit (proposal). All dimensions are in cm.
24. **UVhousing5** (AutoCAD LT file). Side view of compact UV disinfection (partly disassembled, proposal). All dimensions are in cm.

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